
CHAPTER 5

RECOMMENDATIONS

The coal reserves of Armenia and the likely cost of coal at a power station have been analyzed within this report in an effort to support the development of a 50 MW power station in Armenia. The overall purpose of this program is to find coal reserves and develop a power station to generate more energy security and independence for Armenia. The following provides Hagler Bailly's recommendations following a review of where the program stands based on over five years of work. This chapter summarizes the primary recommendations and provides a basic discussion regarding the recommendations.

Chapter 2 analyzes the coal deposits evaluated so far by the U.S.G.S. and concludes that adequate coal resources appearing economically mineable in sufficient quantities to support a 50MW coal-fired power station have not been identified. The overall quantity and quality of carbonaceous shale in the Shamut deposit is likely inadequate for a 50MW coal-fired power station. The only coal deposit remaining that may hold any promise is the Ijevan deposit located in northeastern Armenia.

All deposits explored to date do not have the potential to provide an economically reliable coal resource for a 50 MW power station. Hagler Bailly recommends that only the Ijevan coal deposits be explored by the U.S.G.S. to determine if a potential coal resource may occur. If coal is not found in sufficient quantities then evaluation concerning the use of low quality oil- shale resources of Dilijan would be the next likely domestic candidate. It is necessary that an analysis of available information from a mineability perspective be conducted to determine if the expense of additional exploration funds in the future appears warranted.

The exploration efforts to date have not identified a solid fuel resource providing the necessary fuel resource volume or economics to support a power plant. Future work will have to focus on solid fuel deposits that are less desirable because of lower heat and higher ash content and poorer economic value. It is necessary to realize the program has almost reached the threshold where exploration will begin to focus on solid fuel resources of significantly less value and higher cost. It is required, therefore, to revisit assumptions and guidelines established for this program relative to meeting energy security goals.

Hagler Bailly recommends that information provided in this report and any subsequent economic analysis relative to a coal-fired power station are employed to analyze the likely economics and cost of developing a potential fuel resource. If the quality and cost of a solid fuel resource delivered to the power station forces the

plant to have a negative internal rate of return and this return will not be satisfactory to any financier, then further exploration is not warranted. This analysis should be used to determine how non-economic or expensive mining ventures would be financed and subsidized on an annual basis in order to support the economics of a coal-fired power station. This exercise should allow rational decisions concerning Armenia's ability to support an expensive energy security policy by setting financial limits dependent on Armenia's financial capability, necessity to attract capital, and donor tolerance.

Guidelines should then be developed for this project to ensure precious donor funds are not poorly employed. These guidelines would be invaluable to evaluate the Ijevan coal deposit and to determine if it is sensible to evaluate resources such as the Dilijan oil shale deposit any further. The purpose of these guidelines would be to establish what level of economic feasibility is required for future solid fuel deposits. This measure can be presented in terms of net present value along with the internal rate of return, and the annual maximum subsidy support capability.

The efforts of the Armenian Coal Exploration and Resource Assessment Program have appropriately focused to date upon locating the best available coal reserves in Armenia. One candidate, Ijevan, appears to hold promise of a decent quality coal with adequate reserves that may be economic. Other known remaining domestic resources include the Dilijan oil shale deposit located northeast of the Sevan Lake. Analyzing low-grade fuel deposits any further will require investigating fuel resources with ash content greater than 50%. Ash content greater than this magnitude will dictate a mine-mouth power station and a much more meaningful ash management plan if ventures are to be economic.

Hagler Bailly recommends that a maximum technical capability description be prepared for a fluidized-bed power station to guide explorers in evaluating sites, such as solid fuel resources with ash greater than 50%, prior to expenditure of further funds. Because it will now be necessary to evaluate more marginal domestic fuel reserves, guidelines and an economic analysis model should also be developed to guide decisions related to economic analysis of fuel resources and power station feasibility. Since capital and operating costs for a standard 50 MW fluidized bed power station were investigated before, there is a need to update this information for cases where fuels have higher ash content, lower calorific value, and higher price assumptions. This model and the guidelines should be prepared to allow explorers the capability to evaluate a fuel reserve so that they can predict the likely economic performance of a specific deposit. In this way, likely economics can be reviewed to determine if they are reasonable enough for further exploration efforts to be pursued. This model should be developed to allow evaluation of both mine site and the Hrazdan power station location options.

The coal resources identified during the coal exploration program were reviewed to determine if a mining cost could be estimated, reasonable for the type of domestic reserves identified, and appropriate for use in economic analyses concerning the coal-fired power station. Because adequate information concerning economic coal reserves is not available, this task can not be accomplished with any reasonable degree of certainty. Nonetheless, because the reserves identified so far all appear to be amenable to a contour-haulback mining method, the costs developed by the U.S.G.S. are assumed to be a reasonable estimate of the likely lower range of economic mining costs. The delivered cost of coal was estimated by using current unit bulk cargo rates for rail.

Hagler Bailly concludes that inadequate information exists to generate reliable cost and fuel quality estimates for confident economic analyses of a 50 MW coal-fired power station. A theoretical delivered FOB rail cost of \$25 to \$57 dollars per metric tonne can be assumed as a reasonable cost for domestic coal delivered to a power station at Hrazdan. The \$57 upper price is an expert estimate based on uneconomic exploration projects in the US. Similarly, a theoretical calorific value of 4,100 kcal/kg, an ash content of 50%, a sulfur content of 3.0%, moisture content of 5% (all as-received basis), and a DAF volatile matter content of 25% are recommended as the domestic design fuel quality characteristics for a coal-fired power station. This estimate incorporates the best available information at this time.

The efforts to develop a domestic coal resource have not yet “borne fruit” and it is possible that after the Ijevan exploration is complete, adequate coal resources may not be found. Because the value of greater energy security is important for Armenia, it is worthwhile to consider coal resources beyond the Armenian border. These resources might provide more energy independence through mutual reliance upon economic goals with Armenia’s neighbors while also encouraging private financing opportunities. Although this alternative is not as desirable as having domestic coal reserves, it is a viable alternative when with having a single source of natural gas.

Hagler Bailly recommends a research program for information on potential coal suppliers and coal resources in the countries bordering Armenia wherein mutual international benefit could result. Opportunities to develop a source of supply from a foreign coal deposit for an Armenian station or to develop power from a foreign mine-mouth coal-fired power plant should be investigated.

To initiate expansion beyond Armenian borders, the Tkibuli mine in Georgia should be considered as a viable option because a mine exists, reserves have been identified, and the Government of Georgia desires to improve the coal-mine driven economy in the Tkibuli region. In addition, a transportation system is in place and a situation exists where dependent reliance between supplier and buyer would act as a long-term cohesive agent. This alternative should be fully investigated, developed, evaluated, and presented to the Government of Armenia as a formal energy security

option against which other options can be compared. With the Government of Armenia's approval, a formal plan and proposal could be developed for the Government of Georgia and to solicit private interest groups. This effort would provide the program with a definite show of success.

Chapter 4 demonstrates that the economic cost of a coal-fired versus a natural gas-fired power station is rather high, at \$50 to \$85 million annually, and therefore should be a serious consideration for a country with limited financial resources. This information is provided as a catalyst to begin asking the question of what energy independence is worth in Armenia. The fact that no significant coal resources have yet been found leads to the possibility that only the low heat content oil shale resource at Dilijan may provide the possibility of adequate domestic quantities of solid fuel that could be used to fire a fluidized bed power station.

Hagler Bailly recommends that information be generated from alternate power generation cases that show the annual cost of alternative independent energy sources, so that decisions can be made about the tradeoff between the cost and value of energy independence for Armenia.

Although adequate reserves have not been found to economically support the financing of a mine for the power station, it could be possible if either the Ijevan coal or possibly the Dilijan shale oil deposits are deemed to be suitable sources. About one million tonnes of economic reserve appear likely at Antaramut and could be a fairly good-sized local supply source. To date, no focus has been exerted on developing a climate in Armenia to attract foreign investment in the mining sector. If this overall project is to be successful, it will be necessary to attract foreign mining companies and financiers to Armenia. Because Armenia does not have adequate funds to explore and develop a mining property, it will be necessary that USAID or another donor fund these work tasks to the point at which foreign mining investors will be attracted. In discussions with foreign professionals working in the mining industry of Armenia, they find it very difficult to work because they can not even generate a letter of credit so that supplies or equipment, which have to be purchased from abroad, can be procured. A new set of mining policies and regulations as well as environmental regulations need to be developed in order to enable Armenia to attract foreign capital into the mining sector.

Hagler Bailly recommends action to begin preparing acceptable regulations and policies for the mining industry so that foreign mining companies and their financiers will be attracted to Armenia. It will also be necessary to ensure that appropriate environmental safeguards are instituted.